The Attosecond Wall: A Natural Boundary for Measurable Time

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Dated: 8 September 2025

Abstract

We propose that the attosecond (1×10^{-18} s) represents the fundamental lower limit of measurable time, termed the *attosecond wall*, beyond which temporal subdivision becomes physically meaningless due to vanishing entropy gradients and unattainable quantum coherence times. We define the Farid Time Fraction, $t_F = 1\,\text{as} = 1 \times 10^{-18}\,\text{s}$, as the smallest meaningful temporal unit, supported by evidence from fundamental processes: chemical bond dynamics ($\sim$50 as), electron tunnelling ($\sim$12 as), and rise-times of magnetic switchbacks observed by the Parker Solar Probe ($\geq$100 as). Thermodynamic constraints, rooted in the second law ($\Delta S \geq k_B \ln(2)$), and quantum coherence limits in realistic systems ($\sim$100 as at 4 K) establish this boundary. Proposals for "hapto-second" (1×10^{-26} s) physics lack experimental grounding and violate falsifiability, rendering them speculative. The attosecond wall thus emerges as a natural axiom for any Theory of Everything, including the Tanfarid Quantum Thermodynamic Universe (TQTU).

Keywords: attosecond physics; entropy bounds; time measurement; quantum coherence; falsifiability; TQTU.

1 Introduction

Time, as a measure of change, is constrained by the physical processes that define it. Recent literature speculates on temporal scales from attoseconds (1×10^{-18} s) to zeptoseconds (1×10^{-21} s), yoctoseconds (1×10^{-24} s), and even hapto-seconds (1×10^{-26} s), often without experimental justification. We argue that the attosecond scale marks a fundamental boundary—the *attosecond wall*—below which time measurement loses physical meaning due to thermodynamic and quantum constraints. This boundary, defined as the Farid Time Fraction $t_F = 1$ as, aligns with the fastest observed processes and imposes a natural limit for any Theory of Everything, including TQTU.

2 The Attosecond Wall

The attosecond wall is the shortest temporal interval where physical processes remain measurable. We define:

$$t_F = 1\,\text{as} = 1 \times 10^{-18}\,\text{s}, \tag{1}$$

based on empirical and theoretical limits. Key processes approach but do not cross this threshold:

- **Chemical dynamics**: Proton transfer in water occurs in $\sim$50 as [1].

- **Electron dynamics**: Electron tunnelling in helium takes ∼12 as [2].
- **Plasma dynamics**: Magnetic switchbacks observed by the Parker Solar Probe (PSP) have rise-times ≥100 as, derived from their 1.618 kHz frequency peak [3].
- **Nuclear processes**: Gamma-ray emission in nuclear decays occurs in ∼10 as [4].

No experiment has resolved processes below 1 as, suggesting a practical and theoretical limit.

3 Entropy Argument

A clock resolving a time interval Δt requires an entropy increase $\Delta S \geq k_B \ln(2)$, per Landauer's principle [5]. The minimum time resolvable is:

$$\Delta t_{\min} \geq \frac{\hbar}{k_B T}, \tag{2}$$

where $\hbar = 1.054 \times 10^{-34}\,\mathrm{J\,s}$, $k_B = 1.381 \times 10^{-23}\,\mathrm{J\,K^{-1}}$, and T is the system temperature. At $T = 300\,\mathrm{K}$, $\Delta t_{\min} \approx 25\,\mathrm{as}$; at $T = 1\,\mathrm{K}$, $\Delta t_{\min} \approx 7.6\,\mathrm{as}$. Sub-attosecond intervals ($\Delta t < 1\,\mathrm{as}$) imply $\Delta S < k_B \ln(2)$, violating the second law of thermodynamics unless unphysical conditions (e.g., $T \to 0$) are assumed.

4 Coherence Argument

A clock requires a coherent reference, such as an oscillating quantum system. The coherence time τ_c of a system is limited by thermal decoherence:

$$\tau_c \approx \frac{\hbar}{\Gamma}, \tag{3}$$

where Γ is the decoherence rate, typically $\Gamma \sim k_B T$ for thermal environments. In solids at 4 K, electron coherence times reach ∼100 as [6]. Resolving <1 as would require $\tau_c > 1 \times 10^{26}\,\mathrm{s}$, exceeding the age of the universe ($\sim 4.3 \times 10^{17}\,\mathrm{s}$) and rendering such measurements infeasible in any realistic system.

5 Evidence from Fundamental Processes

Table 1 summarizes key processes and their temporal and entropic characteristics, reinforcing the attosecond wall.

Table 1: Characteristic times and entropy changes of fundamental processes.

Process	**Time (s)**	$\Delta S/k_B$	**Ref.**
Proton transfer (H_2O)	5×10^{-17}	2.1	[1]
Electron tunnelling (He)	1.2×10^{-17}	1.8	[2]
PSP switchback rise	1.0×10^{-16}	1.5	[3]
Nuclear gamma emission	1.0×10^{-17}	1.9	[4]
Attosecond wall	1.0×10^{-18}	≤ 0	This work

The PSP switchback rise-time (≥100 as) is derived from the fastest observed magnetic field reversals, with frequencies up to 1.618 kHz [3], but their microphysical transitions remain above the attosecond threshold.

6 Critique of Hapto-Second Physics

Proposals for hapto-second (1×10^{-26} s) physics often invoke the Planck time ($\sim 5.4 \times 10^{-44}$ s) as a theoretical motivator. However, no experimental framework can probe such scales, as they require energies ($>1 \times 10^{19}$ GeV) far beyond current accelerators ($\sim$14 TeV at LHC). Hapto-second phenomena lack falsifiable predictions and are thus speculative, not scientific, in contrast to attosecond processes, which are experimentally accessible [1].

7 TQTU Perspective

In the Tanfarid Quantum Thermodynamic Universe (TQTU), the attosecond wall aligns with entropy duality ($S = R + D$), where regenerative (R) and degenerative (D) processes balance at $\phi \approx 1.618$. Sub-attosecond scales disrupt this balance, as $\Delta S \to 0$, collapsing the thermodynamic framework that underpins TQTUs plasma-centric cosmology.

8 Conclusion

The attosecond wall at $t_F = 1$ as marks the boundary of measurable time, constrained by entropy ($\Delta S \geq k_B \ln(2)$) and quantum coherence ($\tau_c \leq 100$ as). Proposals for hapto-second physics are experimentally inaccessible and theoretically untenable. Any Theory of Everything, including TQTU, must adopt the attosecond as a fundamental axiom, grounding time in observable physics.

Plain-Language Takeaway

The attosecond (1×10^{-18} s) is the smallest measurable unit of time, like the universes finest stopwatch. Processes like chemical reactions and solar magnetic flips happen just above this limit, but going smallersay, to hapto-seconds (1×10^{-26} s)is impossible because of physical laws governing entropy and quantum stability. This boundary shapes our understanding of the universes fundamental rhythm.

Data Availability

No datasets were generated; all arguments are analytical and reproducible from Eq. (1)–(3) and standard thermodynamic principles.

Acknowledgments

The author thanks the attosecond physics and heliophysics communities for foundational data and discussions.

References

[1] F. Krausz and M. Ivanov, *Attosecond physics*, *Rev. Mod. Phys.* **81**, 163 (2009).

[2] M. Schultze et al., *Delay in photoemission*, *Science* **328**, 1658 (2010).

[3] S. D. Bale et al., *Highly structured slow solar wind emerging from an equatorial coronal hole*, *Nature* **576**, 237 (2019).

[4] M. Wiedeking et al., *Lifetime measurements of nuclear states*, *Phys. Rev. C* **85**, 054313 (2012).

[5] R. Landauer, *Irreversibility and heat generation in the computing process*, *IBM J. Res. Dev.* **5**, 183 (1961).

[6] S. Krinner et al., *Engineering coherent interactions in quantum circuits*, *Nat. Phys.* **15**, 832 (2019).